FOREST PEST MANAGEMENT
Pacific Southwest Region

Report No. 86-6

3420 Pest Management Evaluations
March 4, 1986

AN EVALUATION OF WIND DAMAGE IN TRUE FIR STANDS ON THE KINGS RIVER RANGER DISTRICT, SIERRA NATIONAL FOREST

Michael A. Fosberg, Meteorologist
John Pronos, Plant Pathologist

ABSTRACT

Extensive blowdown in true fir shelterwood cuts occurred during two consecutive winters on the Kings River Ranger District. Mono winds were the primary cause; several pests were present but did not play a significant role in the wind damage. Similar windthrow can be expected unless current cutting practices are modified. Six management alternatives addressing the blowdown situation are presented.

INTRODUCTION

During the winters of 1983/84 and 1984/85, substantial numbers of large sawlog-size conifers, predominantly true fir, were either uprooted or broken off by wind. The exact dates on which the blowdowm took place were unknown because the area is not accessible during winter months. Damage occurred within shelterwood and sanitation cut blocks and adjacent to clearcuts on the north and northeast sides of Patterson Mountain. Unscheduled stand entries were required to salvage more than 10 MM board feet of damaged timber. The effect that this blowdown may have on regeneration efforts is unknown.

The Kings River District began using shelterwood systems, instead of clearcuts, in the fir type about 1980, and current management plans call for continuing the use of shelterwood cuts. Future harvest plans need to be critically evaluated in light of this blowdown situation.

On July 29-31, 1985, Forest Service specialists examined wind damaged areas on Patterson Mountain. Personnel participating included Mike Fosberg, meteorologist - PSW, Riverside; John Pronos, plant pathologist - Forest Pest Management, RO; Mark Smith, silviculturist - Sierra National Forest; Ed Becker, District Timber Management Officer; and John Wambaugh, District Small Sales Officer. The objectives of the evaluation were to 1) determine meterological aspects of the wind-throw, 2) determine whether any diseases, particularly root rots, were involved, and 3) formulate management alternatives that might reduce future damage.

USDA, FOREST SERVICE, PACIFIC SOUTHWEST REGION
State and Private Forestry, Forest Pest Management
630 Sansome Street, San Francisco, California 94111

OBSERVATIONS AND DISEASE CONDITIONS

In several shelterwood areas one-third to one-half of the residual trees were windthrown. About 50 trees in 10 different cut blocks were examined for pest conditions that could have contributed to failure. Most tree damage was due to uprooting rather than stem breakage. In fact, several dominant trees with either dwarf mistletoe bole cankers or Indian paint fungus conks were still standing near down trees that had no visible defects. Both dominant and codominant trees in shelterwoods sustained wind damage; intermediate trees were much less affected.

Only two trees that failed in the butt log had any detectable decay at the point of breakage. Under normal conditions the amount of decay present would not have been considered great enough to predispose these trees to failure.

About one-fourth of the uprooted trees had some evidence of root disease, but rarely were more than one or two of the major structural roots affected. Trees with root rot commonly had only 10-15 percent of their root system decayed, which would not usually play a significant part in tree failure. Based on the general appearance of most areas visited, we concluded that winds had been strong enough to knock trees down without any root decay or stem defects.

Armillaria sp. was the most commonly found root disease fungus, with Fomes annosus occurring infrequently. Armillaria is a natural inhabitant of fir stands that normally causes little damage. Its ability to impact conifers through root decay is greatly increased where soils are very wet or saturated for extended periods. A few areas on Patterson Mountain are poorly drained, and this is where we would most likely expect root disease to play an important role in tree failures during strong winds. However, wet soils, even without root rot pathogens, are particularly prone to wind damage. Fomes annosus causes significant decay of structural roots in many California fir stands, but its occurrence and impact on Patterson Mountain were surprisingly low.

METEOROLOGICAL CONSIDERATIONS

Two possible meteorological events were identified which could produce winds strong enough to account for the damage observed on the mountain. These are Mono winds over the central and southern Sierra Nevada, and winter cold front storms. Winter cold front storms approach the Sierra Nevada from the west and are accompanied by first, southwest winds at ground level, then by west or northwest winds after the storm front has passed. These storms are also accompanied by a strong low level jet stream of southerly winds along the western face of the Sierra Nevada (1). The second probable meteorological situation is Mono winds. Mono winds are northeast or east winds across the crest of the Sierra Nevada and vary markedly in intensity. These Mono winds tend to be strongest on exposed ridges and peaks.

Wind penetration into dense forest canopies decreases rapidly from a clearing edge (table 1). The density of the foliage in the canopy also alters the wind penetration from the top of the canopy. In a stand with little foliage, windspeeds may be twice that of wind with dense foliage (2). The effects of wind in openings (clearcuts, right-of-ways), and where small groups of trees have

been removed depend on the size and shape of the opening. In large openings, strong winds readily reach the ground and exert strong forces on the windward side of the clearing. Also, considerable turbulence is generated by the opening (fig. 1). In addition, the wind direction is for the most part opposite that in the opening. A whirl forms between surrounding, protective old stands and causes frequent reversal of wind direction at ground level. The upper wind extends inward only partially. In contrast, a thinned stand allows greater wind penetration and is less able to generate turbulence than a dense forest, but is more prone for strong gusts to reach lower levels in the canopy (3). Winds in a right-of-way or long narrow cut are dependent on the wind direction relative to cut orientation (fig. 2). The 200 foot-wide power line right-of-way constructed for the Helms Project was not judged to be a contributing factor in the overall blowdown situation on Patterson Mountain.

Table 1 - Windspeed in a dense canopy as a percent of outside windspeed (2)

DISTANCE FROM EDGE	PERCENT WINDSPEED
50 m	55 - 75
70 m	24 - 27
100 m	7
200 m	2

Windthrow of trees is more directly related to wind fluctuations (turbulence) than to total windspeed. In either winter storms or Mono winds, the standard deviation of the windspeed is about one-half the total windspeed (2). That is, winds fluctuating plus or minus one standard deviation about the mean windspeed show a range of windspeeds equal to the mean windspeed. The time interval over which the fluctuations occur is from a few seconds to a few tens of seconds. If the trees are shallow rooted, and not wind hardened, and are exposed to turbulence through thinning or openings in the stand, chances of windthrow are increased.

Observed windthrow patterns on Patterson Mountain

In order to determine the meteorological events occurring during the blowdown periods, indirect indicators of wind direction had to be used. Wind direction was assummed to be parallel to the direction of the fallen trees, with the wind blowing from the roots toward the crown. The tree-fall patterns on the north and northeast sides of Patterson Mountain showed a fairly uniform pattern indicating northerly winds in the shelterwood, sanitation, and other partial cuts (fig. 3).

An effort was made to look at tree-fall patterns in uncut areas, both on Patterson Mountain and on the north side of Dinky Creek. Down trees in the uncut areas were far fewer in number and showed more variation in wind direc-

Figure 1. Wind movement in an opening and in a thinned strip. The windspeed under the thinned strip averaged one and a half times greater than in the opening (3).

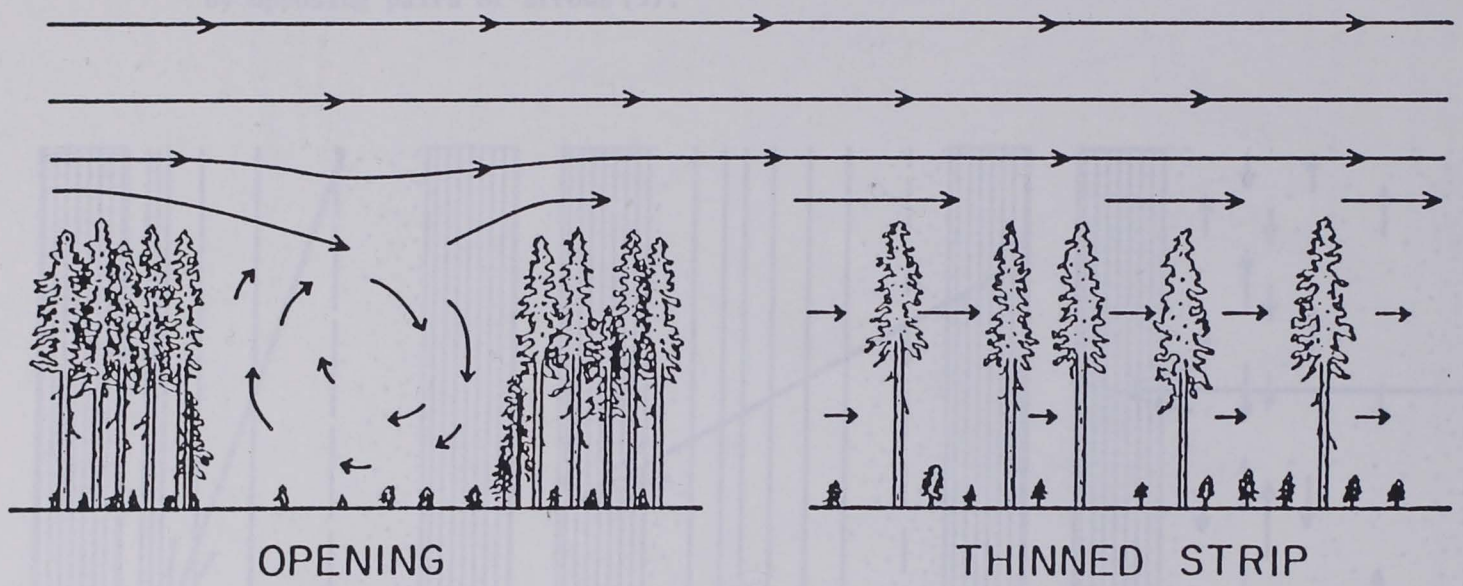


Figure 2. The wind motion in a forest cutting in relation to the upper wind shows schematically the results of Geiger's measurements. The heavy arrow represents the wind aloft, over the cutting; the small arrows, the winds in the cutting. The stronger the winds, the closer the lines. Dotted areas indicate dead air spaces. If the wind is blowing perpendicular to the course of the cutting, the wind gusts above the cutting are indicated by opposing pairs of arrows (3).

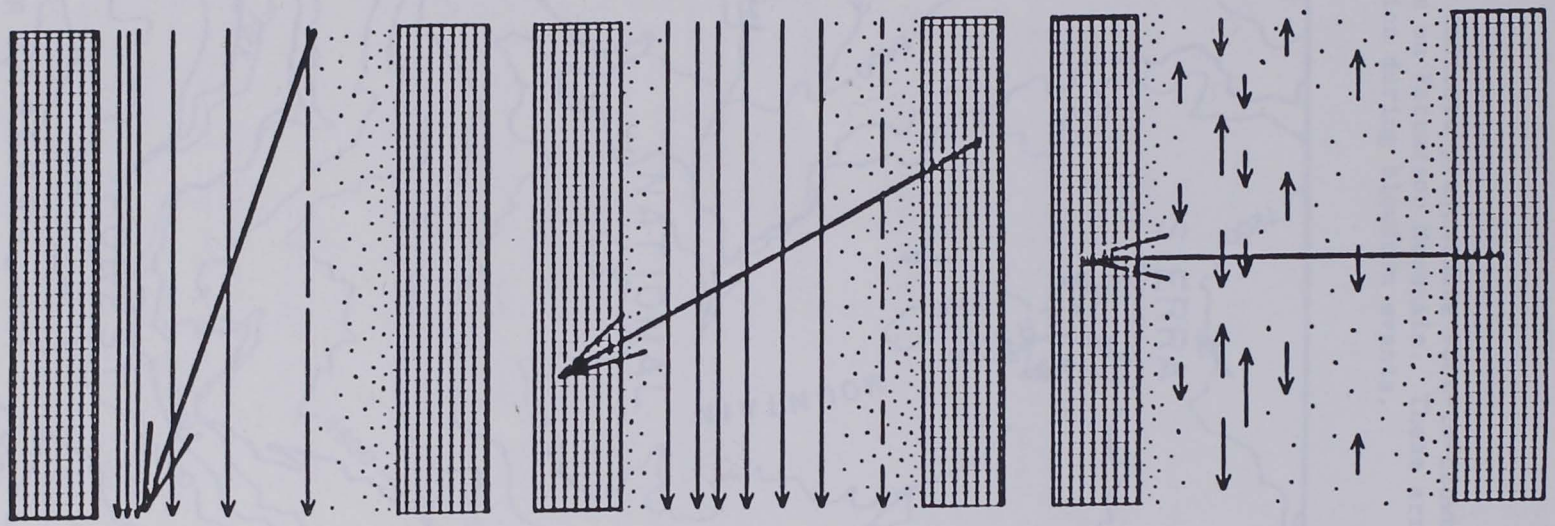
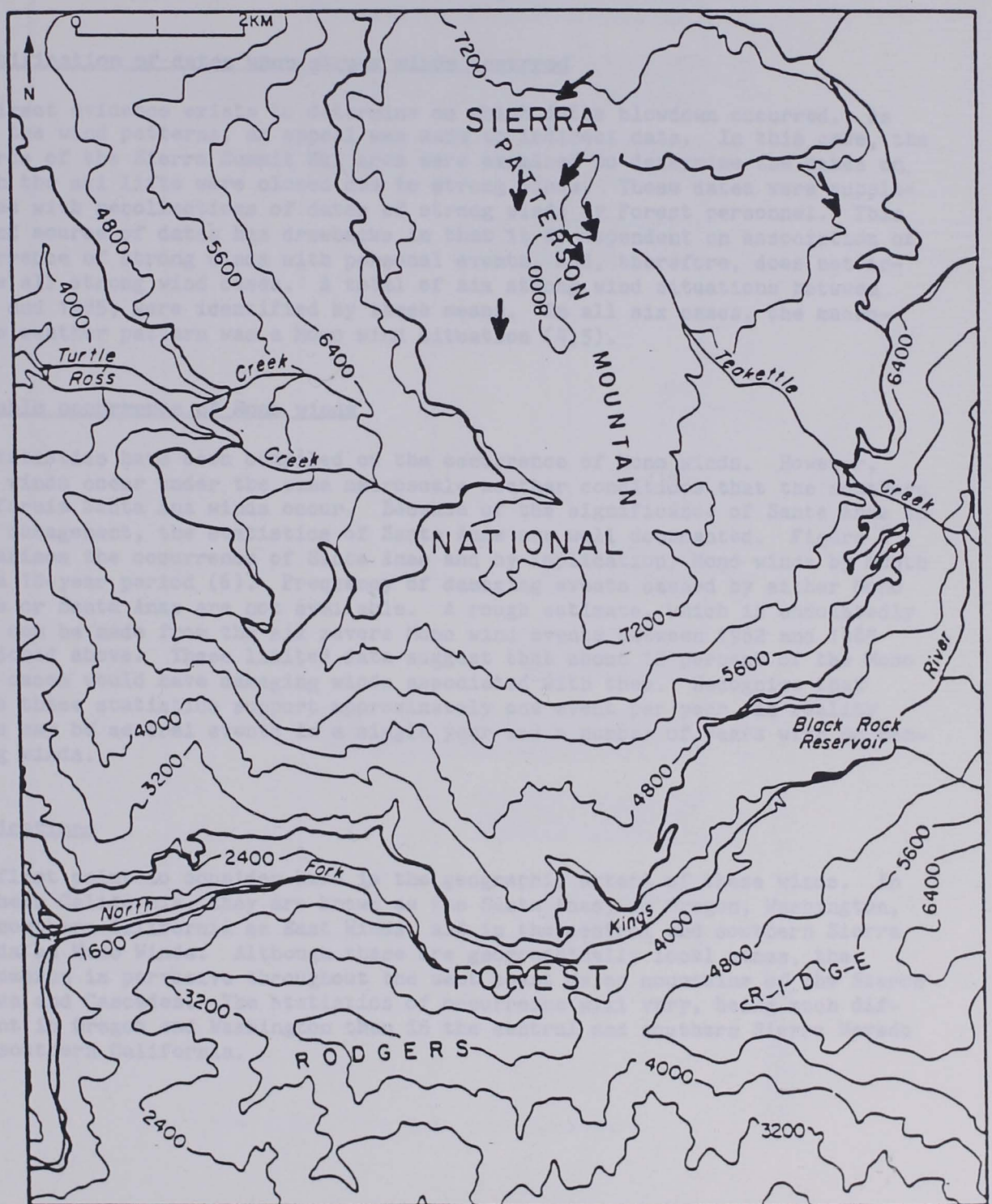


Figure 3. Bold arrows indicate predominate root-to-crown direction of fallen trees on Patterson Mountain. These arrows indicate wind direction during blowdown events.



tion. Even so, the majority of down-trees showed a wind direction of north and northeast. An additional effort was made to locate down trees which had been on the ground for a long time. These old, down trees (rotten logs) also showed the north and northeast wind pattern in both uncut and old cut areas, suggesting that these north and northeast winds had produced blowdown over a long period of time.

These indirect data on wind direction patterns suggest that the blowdown occurred during Mono winds rather than during winter storms.

Identification of dates when strong winds occurred

No direct evidence exists to determine on which dates blowdown occurred. As with the wind patterns, an appeal was made to indirect data. In this case, the records of the Sierra Summit Ski area were examined to determine the dates on which the ski lifts were closed due to strong winds. These dates were supplemented with recollections of dates of strong winds by Forest personnel. This second source of dates has drawbacks in that it is dependent on association of occurrence of strong winds with personal events, and, therefore, does not include all strong wind cases. A total of six strong wind situations between 1982 and 1985, were identified by these means. In all six cases, the macroscale weather pattern was a Mono wind situation (4,5).

Probable occurrence of Mono winds

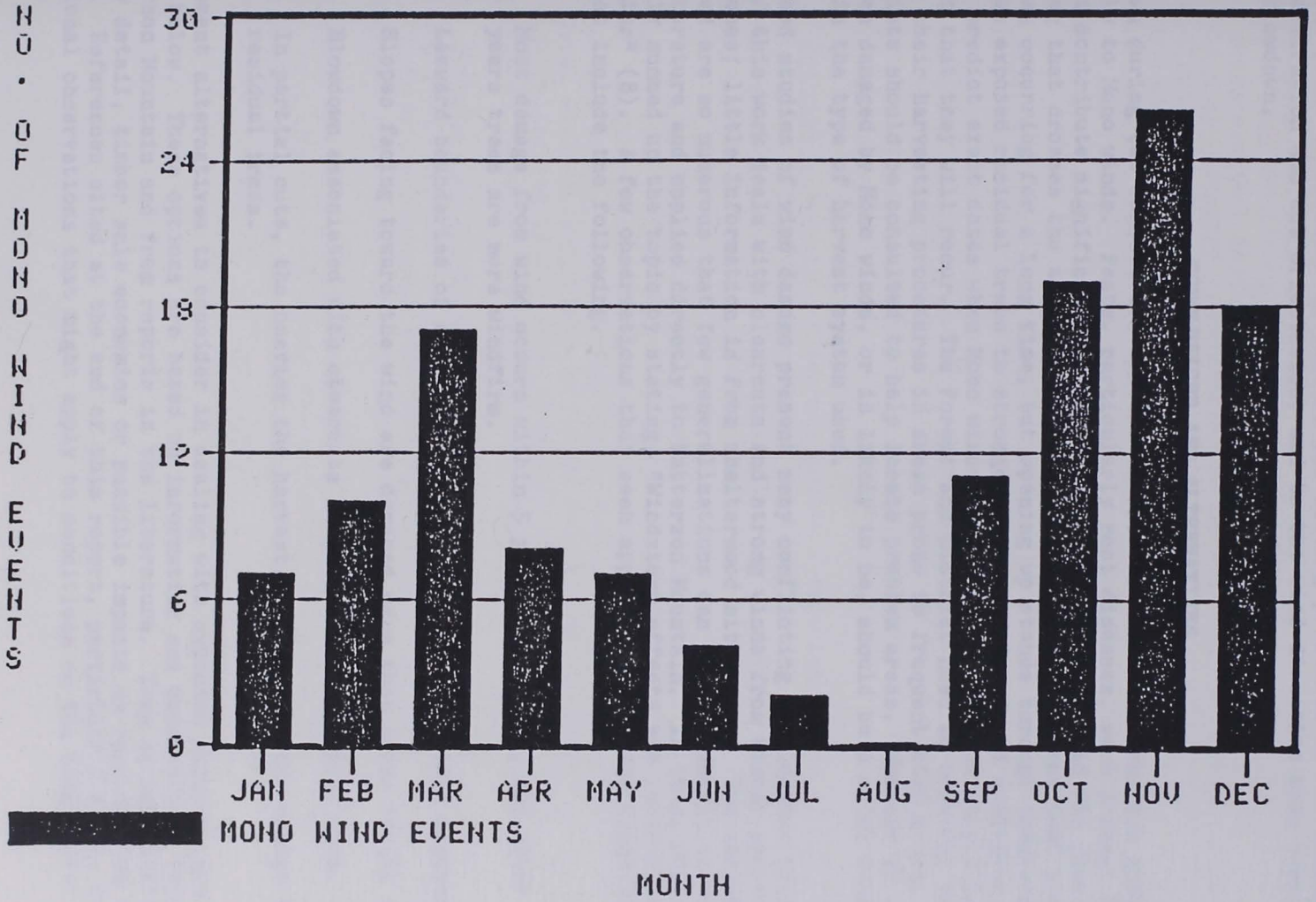
No statistics have been compiled on the occurrence of Mono winds. However, Mono winds occur under the same macroscale weather conditions that the southern California Santa Ana winds occur. Because of the significance of Santa Anas in fire management, the statistics of Santa Anas are well documented. Figure 4 summarizes the occurrence of Santa Anas and by implication, Mono winds by month for a 10-year period (6). Frequency of damaging events caused by either Mono winds or Santa Anas are not available. A rough estimate, which is undoubtedly low, can be made from the six severe Mono wind events between 1982 and 1985 mentioned above. These limited data suggest that about 12 percent of the Mono wind cases would have damaging winds associated with them. Recognize that while these statistics support approximately one event per year, in reality there may be several events in a single year and a number of years with no damaging winds.

Implications

The first point to consider here is the geographic extent of these winds. In southern California, they are known as the Santa Anas, in Oregon, Washington, and northern California as East Winds, and in the central and southern Sierra Nevada as Mono Winds. Although these are geographically local names, the phenomenon is pervasive throughout the west coast major mountains of the Sierra Nevada and Cascades. The statistics of occurrence will vary, being much different in Oregon and Washington than in the central and southern Sierra Nevada and southern California.

FIGURE 4. FREQUENCY OF MONO WIND EVENTS BY MONTH, 1951-1960

(SCHROEDER ET AL., 1964)



The second point to consider is which areas are wind prone. For Mono winds, these are high elevation ridges and peaks. To a lesser extent, canyon mouths are affected.

The final point to consider is that of the cutting practices in relationship to wind penetration and cut orientation, and to the wind direction most likely to cause blowdown.

CONCLUSIONS AND ALTERNATIVES

Blowdown during two consecutive winters on Patterson Mountain was due almost entirely to Mono winds. Pests, particularly root diseases, were present but did not contribute significantly to actual tree failure, nor did the power line clearing that crosses the area. Tree-fall examinations indicated that blowdown has been occurring for a long time, but opening up stands through shelterwood cuts has exposed residual trees to stronger winds and increased windthrow. We cannot predict exact dates when Mono winds will occur, but we certainly can predict that they will recur. The Forest and District need to consider modifying their harvesting procedures in areas prone to frequent high winds. Soil scientists should be consulted to help locate problem areas. Whether an area has been damaged by Mono winds, or is likely to be, should be a major consideration in the type of harvest system used.

Published studies of wind damage present many conflicting conclusions (7,8,9). Most of this work deals with clearcuts and strong winds from winter storms or hurricanes; little information is from shelterwood situations. The variables involved are so numerous that few generalizations can be confidently taken from the literature and applied directly to Patterson Mountain. In 1943, Curtis cleverly summed up the topic by stating, "Windstorm effects are invariably irregular" (8). A few observations that seem appropriate for the Kings River District include the following.

1. Most damage from wind occurs within 5 years of cutting, and after 10 years trees are more windfirm.

2. Leeward boundaries of clearcuts sustain more blowdown than windward.

3. Slopes facing toward the wind are damaged more than those facing away.

4. Blowdown associated with clearcuts is less than in partial cuts.

5. In partial cuts, the heavier the harvest, the heavier the damage to residual trees.

Management alternatives to consider in dealing with expected blowdown are outlined below. These options are based on information and observations from Patterson Mountain and from reports in the literature. They do not consider, in any detail, timber sale economics or possible impacts on regeneration efforts. References cited at the end of this report, particularly 7 - 9, contain additional observations that might apply to conditions on the Kings River District.

1. Continue current practices. Because we assume that Mono winds will recur, continued blowdown damage is expected in future shelterwood cut blocks on the mountain. There is no reason to expect the level of damage will be different from that experienced during the past two winters.

2. Modify shape, orientation, and location of cut blocks. Square-shaped shelterwood cuts that leave 12-15 trees per acre appear to be especially prone to Mono wind damage. Studies on winter storm damage (not Mono winds) and meteorological input suggest that shelterwood or clearcut strips, 2-3 chains wide, oriented perpendicular to the direction of damaging winds, would reduce windthrow. Alexander (9) recommends placing initial cutting units (his work involved only clearcuts) farthest away from the direction of strong winds and then making a progression of cuts towards the wind. In all cases, laying out cutting units must include information on how the topography is expected to affect windthrow.

3. Leave smaller trees in shelterwood. Observations on Patterson Mountain indicated that trees most often windthrown or uprooted were dominants and codominants; most intermediate trees were unaffected. This does not agree with reports on winter storm damage to trees along clearcut edges (7). Trees left in shelterwoods on the Kings River District have generally been larger than 24 inches dbh. Perhaps leaving fir smaller than this would reduce windthrow.

4. Use more clearcuts. Clearcuts probably experience less damage per unit area because only trees adjacent to the boundary are subject to windthrow. Larger clearcuts sustain the least overall wind damage, while groups of small clearcuts have been heavily damaged.

5. Treat wet areas separately. More windthrow can be expected in wet areas because of less soil/root support and shallower root systems. In addition, Armillaria root disease, if present, tends to be more damaging in saturated soils. Clearcutting may be better in these stands unless tree removal will cause the soil to become even wetter and create problems in regenerating the site. Input from soil scientists should be standard procedure in prescriptions written for these sites.

6. Promote more windfirmness in trees. For existing stands, schedule a commercial thinning approximately 10 years prior to the sheleterwood cut. In plantations, maintain wide spacing throughout the life of the stand, to increase stem taper and root development.

While there are no guarantees that any of steps 2-6 will eliminate windthrow, we feel that the District should first identify all areas that are likely to sustain wind damage, and then evaluate some or all of these alternatives during future timber sales.

References

1. Waight, Kenneth T.; Parish, Thomas R.; Marwitz, John D. Numerical simulation of barrier winds with diabatic influences. In: Proceedings of the Third Conference on Mountain Meteorology. Conference Volume; 1984 October 16-19; Portland, OR. Boston, MA: American Meteorological Society; 1984.

2. Yoshino, Masatoshi M. Climate in a small area. Tokyo: University of Tokyo Press; 1975. 549 p.

3. Geiger, Rudolf. The climate near the ground. Cambridge: Harvard University Press; 1959. 449 p.

4. U.S. Department of Commerce. Daily Weather Maps. Washington, DC: U.S. Government Printing Office. NOAA; 1982.

5. U.S. Department of Commerce. Daily Weather Maps. Washington, DC: U.S. Government Printing Office. NOAA; 1985.

6. Schroeder, Mark J; Glovinsky, Monte; Hendricks, Virgil F.; and others. Synoptic weather types associated with critical fire weather. Berkeley, CA; Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture. 1964; 492 p.

7. Gordon, Donald T. Damage from wind and other causes in mixed white fir-red fir stands adjacent to clearcuts. Berkeley, CA; Pacific Southwest Forest and Range Experiment Station, USDA Forest Service Research Paper PSW-90. 1973; 22p.

8. Curtis, James D. Some observations on wind damage. Journal of Forestry, 41:877-882. 1943.

9. Alexander, Robert A. Minimizing windfall around clear cuttings in spruce-fir forests. Forest Science, 10:130-142. 1964.

FOREST PEST MANAGEMENT
Pacific Southwest Region